Implications of Automated Highway Systems on Land Use Patterns.

Prepared for the National Automated Highway System Consortium Land Use Panel

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August 1996

Abstract:

The potential impacts of automated highway systems (AHS) on land use can be analyzed by looking at basic travel choice theory, the relationships between land use and transportation and experiences with similar systems in the past. AHS demand is seen to be dependant upon the degree to which it can provide travel time savings over conventional travel. This would require significant speed advantages and/or long trip lengths to overcome additional time that may be required for vehicle validty checks and access to a AHS system. Widespread implementation of AHS would be likely to cause displacement and proximity effects on land use near new facilities. In addition there would likely be as area wide consequences from a pattern of decentralization of land use. The more successful the AHS, the more it is likely it is to have effects on land uses. These impacts are likely to be hotly debated at the time of deployment of AHS. Major questions would be raised if and when AHS are intended to be widely implemented which will generate significant debate dominated by non-technological issues.

Introduction:

At first glance it would appear to be very difficult to predict the effects of a radically new transportation technology such as Automated Highway Systems (AHS) upon regional land use patterns. Little is known about exactly how the technology would function or how it would interrelate with land use. Furthermore, our understanding of transportation/land use interactions and how current technology affects it is limited. However upon further examination and by relying on what we do understand about the travel choice process, the land use development process and experiences with comparable systems, we can begin to discuss the impacts with some insight.

This paper has four components: a discussion of travel choice as it relates to Automated Highway systems, a discussion of the relationship between transportation and land use, a discussion of past experiences with technologies similar to Automated Highway Systems and a discussion of the potential impacts of AHS on regional land use patterns. For the purposes of this paper it will be assumed that the technical problems of automated highway systems have been solved and that AHS is seriously being considered for implementation on a wide scale in urban areas. It is assumed that issues of "will it work?" have been solved and AHS is looked at as another option in the same way that freeway expansion, high occupancy vehicle lanes and forms of rail transit such as light rail are looked at now. Given this assumption, the focus of this paper will be of how AHS might be treated in debates about its implementation, especially as they relate to land use issues. For this paper we will rely on our understanding of basic travel choice and land use theory as the basis to make statements of land use effects of AHS.

Travel Choice Behavior:

Travel choice is a general term to represent the options that users of transport have in their trip making decision. When a consumer or shipper has a travel need they need to make a number of decisions. These include the choice of a destination, the choice of mode, the choice of a route, the choice of when to travel, the choice to combine the trip with other trips, and the choice of whether to make the trip at all. In addition travelers and shippers also have longer run choices to shift their home or business locations to deal with travel difficulties. For each of these choices, there are a variety of options and certain principles are used to forecast travel demand for diverse technologies which can help in an examination of AHS. The ones most relevant to AHS are the idea of abstract modes, the concept of disutility minimization and the principle of equilibrium.

Abstract modes: An underlying concept in our understanding of travel choice behavior is the concept of abstract modes. An early application of this idea was in the Northeastern Corridor Transportation Project where it was used to forecast demand for high speed rail transportation between Washington, D.C., New York and Boston in the 1960's. The situation faced then is similar to that faced with AHS. A new technology (high speed rail travel) was being proposed as a means to improve travel in the Northeastern United States. Its principle advantage was expected to be travel time savings over the conventional automobile and other modes. Under the principle of abstract modes, travelers and shippers are assumed to make choices among alternatives on the basis of their perceived performance characteristics, not on the basis of their technology. Choices would be estimated on the basis of such factors as: travel time (in-vehicle time), perceived out of pocket costs, convenience (usually measured as the time spend outside of a vehicle for walk access, waiting, etc.) and comfort'. Other variables such as safety and security are sometimes also important if there are significant differences between the options available. With the principle of abstract modes, there is no such thing as a demand for automated highway systems, but rather a demand for an option with a better performance than other available choices. Thus AHS would only be used to the extent that it has an in-vehicle time, cost, or out-of-vehicle time advantage over other modes. A comparison to conventional automobile travel would suggest that AHS trips would have the same level of convenience (out-of vehicle time) and comfort as regular auto use, higher costs (added equipment cost, road tolls) but reduced travel times. In order for AHS to be attractive to users it would need a time savings advantage that significantly outweighs any increased costs that the use of AHS might involve. This time savings advantage would have to be over and above any additional time that may be involved in the use of AHS. These additional times would include the time required to have validity checks upon entering an AHS, extra time to access an AHS and time involved in congestion that may occur upon leaving an AHS facility. Users of AHS would likely be individuals who have a high value of time and are willing to incur additional expense to achieve a time savings. This implies a user group of higher income individuals, business travelers and shippers of high value commodities.

Speed Time Relationships: Abstract modes tells us that travelers do not choose on the basis of speed but on the basis of travel time. An interesting phenomenon that should be mentioned is the hyperbolic relationship between speed, distance and travel times. Travel time is found from distance divided by speed. As the length of a trip increases, time savings with a high speed system increase directly with distance. That is the minutes saved will double with a doubling of distance. On the other hand as speed increases, time savings increase at a decreasing rate (inverse). Thus, every fixed increase in speed will a smaller effect on the time savings than the previous increase in speed. Accordingly AHS will have time advantages over conventional travel only if trip lengths are long and/or if speed differentials between AHS and conventional travel are large. This is further complicated by the access issue to an AHS system. The access portion of a trip using a high speed mode, can be a significant component of total trip time. If the high speed services are distant from actual origins and destinations, or the network density of high speed services is small, the possibility of time savings becomes less. Thus, AHS would need a wide availability in order to produce significant usage.

Equilibrium: Another important concept in travel choice is the concept of equilibrium. In areas of significant travel, transportation supply and demand are always moving toward a state of equilibrium. Excess demand at one location will redistribute itself to other locations, routes, modes and times of the day. Travelers and shippers cope with congestion by shifting their destination, mode, route and time of travel in order to accommodate their travel needs. Thus, for example, peak hour flows on urban freeways are always at near capacity conditions. Increases or decreases in transportation capacity on urban freeways quickly reach a new equilibrium with nearly identical performance characteristics as the system before the changes. For AHS this can mean that traffic diverted off of a regular highway will soon be replaced by traffic from other facilities, modes, or times of the day. This may lead to travel time savings for non-users of the AHS, but it would only be properly assessed by a process that considers the equilibrium consequences. Time benefits may not necessarily occur with a new equilibrium. If, for example AHS leads mostly to time of day shifts, the overall benefit to non-users would be less than if it led to route shifts. Land use effects are directly related to time savings impacts and their associated effects on land use accessibility that occur under new equilibrium conditions.

Travel Growth? An assumption made by the AHS community is that travel will continue to grow into the future at a rapid rate as it has in the past. This assumption needs to be carefully examined by looking at the underlying causes of previous travel growth. It is true that travel has grown much more rapidly than the population during most of the past twenty or more years. However, this trend might not continue. Rapid travel growth has occurred largely for two reasons. First, during the past twenty years there has been a major change in the travel patterns of women. Twenty years ago, women made fewer trips than men. As women have entered the work force, this has changed and now the travel patterns of women resemble those of men. Second, there has been a significant decline in the amount of car pooling and ride sharing since the fuel shortage crisis of late 1970's. The overall average vehicle occupancy for all trip purposes has declined from 1.9 persons per vehicle in 1977 to 1.6 per vehicle in 1990. Declines for work trips have been even more severe, to a level of 1.14 by 1990 (Pisarski, 1992). Changes in women's travel pattern and declines in vehicle occupancy have both reached a point where they will level off and no longer contribute to a rate of travel growth much faster than population growth. Travel patterns of women will no longer be catching up to those of men and auto occupancies will not fall below one person per vehicle. In addition the aging of the population will also have an effect on travel growth. Older adults will likely continue to use the automobile, but the miles they travel per year will likely decline and there will be shifts in the times of day of that they travel. A final factor that needs to be considered in forecasts of future travel is the uncertainty in the future costs of travel. Perceived costs of travel could rise for a variety of reasons: increased fuel taxes, increased world petroleum prices (foreign fuel dependency has increased back to levels that existed at the times of energy crisis of the 70's); changes in how insurance costs are paid for ("pay-as-you-drive" insurance); cash-out of employee paid parking; other parking pricing changes; implementation of congestion pricing, all have some potential to occur and would affect the perceived price of using an automobile. If such of these occur, they would lead to increases in the costs of travel which would affect the rate of travel growth.

Land Use Behavior:

LandUse/Transportation Interaction: Transportation is one of many factors that affect land use patterns. Land use patterns in the United States are the result of developer/financier/political decisions at the local level that respond to market demand for housing, employment, goods and services. Developers and the institutions that finance development are motivated by a desire to maximize their after tax return on investment. As such they will seek ways to convert vacant land or underutilized land into projects that can generate profit from serving a market demand. "Location, Location, Location" is often given as the three factors that are used to decide where and how to develop. From a transportation perspective, location converts into "access, access, access", that is the ease of getting to a location (time, cost and convenience) compared to other locations. As transportation systems change, increased accessibility to new areas will make them attractive for development. If accessibility increases substantially in rural areas relative to land cost, this will make the rural areas attractive for development and leads to a more decentralized land use pattern.

A common way to think of the relationship between land use and transportation is this is the concept of the thirty minute circle'. Throughout time, it is felt that people are generally willing to commute about thirty minutes to their place of work. At those times when the only means of transport was to walk, cities needed to be highly compact to accommodate the activities within a 30 minute walking distance. As the speeds of travel increased, cities could spread out to wider areas covered at higher speeds. The thirty minute time remains constant, but higher speeds lead to wider distances. Significant increases in speed would be expected to lead to greater travel distances, and a larger 'thirty minute circle'.

It should also be noted that if a high quality transportation system is provided everywhere, there will be little differential effects on land use. That is, all areas will experience the same effect and no one area will have an advantage over another because of better transportation service. If the transportation service gives better access to outlying land in all cases, all of this land becomes attractive to develop because of its relatively low cost. This could in turn accelerate the spreading effects of transportation. Finally it should be mentioned that the magnitude of land use changes will be significant or not depending on how far you look into the future. Short term horizons lead to a higher percentage of future land use that is already in place. Longer term view will show greater effects. In the case of AHS, the impacts are likely to occur over very long time periods and should be examined accordingly.

Community Decisions: Development projects need approval from local governments and their elected representatives to proceed. The goals of local government and local politicians are different than those of developers. Local government seeks to respond to its constituents to meet their desires. In some cases, local government seeks to have projects which they feel will generate tax revenue for the community. In other cases, idealistic goals are adopted about the future of the community and used as the basis to shape development. In either extreme, decisions are seldom made with any realistic information of their consequences. Little is actually known of the long term financial or environmental consequences of land use decisions nor is there generally any discussion of the interrelationships of different projects. Local land use decisions are incremental and occur on a month by month basis. While it may be desirable to take a long term view, this seldom happens in practice. Local government tends to focus on an individual development and its details as it goes through an approval process. Furthermore there tends to be little knowledge (or concern) of what is happening in surrounding communities and how the project will affect them.

The result of these circumstances is that efforts to control and direct land use have been largely ineffective in the United States. Zoning which may seem to have an effect, often can be changed to meet the needs of a project. Land use controls tend to have the most effect when they are used to prevent a situation with clear harm to the community or the environment (such a protection of wetlands) or where there is substantial local citizen opposition to a project. The implications of this on AHS is that it is not appropriate to assume that land use controls could be used to minimize any negative consequences it may have on land use. Land use impacts will occur as dictated by the market unless there is some major initiative to change current procedures.

Concepts Similar to AHS:

There have been several technologies both proposed and implemented, that have had performance characteristics similar to AHS. These have included PRT/Dual mode systems discussed in the 1970s, Pallet type systems used for freight services and some passenger services, toll roads and HOV facilities. Each of these was (or is) expected to provide significant time savings over other systems with various degrees of additional cost or inconvenience. It is interesting to examine these technologies and the lessons learned in their implementation in order to asses how AHS will fare and what impact it may have on land use pattens.

PRT/Dual Mode Systems: The concept of personal rapid transit (PRT) was extensively analyzed in the 1970's. Specialty conferences were held on the topic and a substantial amount of research was done on issues of technology development and deployment (for example see TRB, SR-170, 1972). PRT systems were intended to operate as automated vehicles on a separate guideways. Each vehicle would be a relatively small, automobile type vehicle that would operate from an origin station to a destination station without intermediate stops and at a high speed. Control of the vehicle would be external and accomplished by the physical guideway and automated control systems. Dual mode extended this concept by allowing the vehicles to operate over local streets like conventional automobiles. Several test systems were built for the Transpo 72 exhibit at Dulles airport near Washington and a field demonstration was also built in Morgantown, W.VA... It is considered the predecessor of people mover systems as used in several downtown areas (Miami, Jacksonville, Detroit) and at larger airports (Atlanta, Dallas-Ft. Worth, Chicago, Seattle, etc.). Full scale deployment of systems which operated at very small vehicle spacing never occurred. Dual mode systems were expected to operate much like AHS is described: on an automated guideway and under operator control for local travel and access to the guideway.

Pallet Systems: Pallet systems are those where a truck or automobile is placed on a carrier that operates over a different guideway. Good examples of this are TOFC (trailer on flat car/freight piggyback) services and the Channel Tunnel between Great Britain and France. With such a system, autos or trucks are placed on a rail car and carried in trains to their destinations. TOFC has had a good degree of success for longer haul truck traffic where there is sufficient demand to offer a regular service. Pallet systems are similar to AHS in that vehicles approach the facility under driver control and then are placed on guideway and operated without driver input. They are expected to provide a time or cost advantages outweigh the additional time or cost involved in accessing the system.

Toll Roads: There has been a renewed interest in toll roads in urban areas during the past few years. Toll roads are seen as ways to provide high speed travel in congested corridors at a premium price and with a funding that is self supporting. New urban area toll facilities have been built in Virginia, Florida, Texas and California. They are expected to have performance levels similar to AHS with a gain in travel time at some additional costs. Pricing of toll roads has been proposed as a way to keep them operating at high speeds in comparison to alternative roads.

HOV Facilities: High occupancy lanes (HOV) and roadways have been built in a number of cities and are being actively discussed in a number of other places. HOV lanes are expected to be managed to provide vehicle users with a time advantage in exchange with a time disadvantage that may be necessary to accommodate the travel needs of the vehicle passengers. HOV facilities can be implemented in several ways: take-a-lane or add-a-lane. Take-a-lane involves the conversion of an existing lane to HOV use, add-a-lane refers to adding an entirely new lane to a freeway. Add-a-lane can be done by placing an additional lane to a freeway adjacent to regular lanes and or by adding a lane that is separated physically from the regular road by barriers or in a separate location. All forms have generated complex issues of implementation. This include the concerns of those who will lose their lanes in the take-a-lane scenario, and concerns about the cost and disruption impacts of add-a-lane. The disruption/ cost issues can be significant. For example in the Milwaukee area, 20 mile barrier separated HOV lanes are expected to cost $420 million dollars and take 10 or more years to implement (WDOT, 1996). A barrier separated HOV lane in each direction will require a minimum of 55 feet of width to be added to the freeway right of way. Most urban freeways were not built with extra space for expansion and the impacts on surrounding neighborhoods and businesses can generated considerable concern. Concerns relate to property taking, increased noise levels, aesthetics and impacts on regional development patterns. HOV lanes are seen as a possible location for AHS facilities. Advocates of AHS would do well to examine the issues and concerns that surround HOV facilities to help assess the ease of AHS deployment. It is likely that AHS implementation would face similar hurdles. AHS implementation may be especially difficult in its early stages when few vehicles would be equipped to use the AHS and those vehicles would tend to be owned by higher income individuals. The social/political/institutional complexities of implementation of new transportation facilities should not be taken lightly or underestimated.

Lessons Learned: What lessons can AHS learn from the experiences with PRT/Dual Mode, Pallet Systems, Toll Roads and HOV facilities? There are several which should be considered:

1. New systems tend to cost more and take longer to implement than expected. This seems to be the case for nearly all of the examples given. A typical experience is that the technology is proves to be more difficult to implement that expected because of reliability and safety concerns. It has been generally found that real world deployment in a variety of operating and environmental conditions presents challenges not foreseen in the technological design. This had led to delays and extra costs.

2. Access issues are important. Systems for providing access to the new technology and dealing with vehicles leaving the system tend to be complex and cumbersome. Complex terminals are needed to check vehicle

validity and/or to load or off load vehicles. These facilities add delay and cost to the system. If the number of entry and exit points are limited, this can in turn lead to substantial amounts of time needed to access the system which may exceed any time savings it presents.

3. Implementation is difficult, lengthy and complex. Issues with the implementation of a new system in an existing area get very complex very fast. Requirements of project implementation and their associated social and political issues as well as financial concerns dominate technological questions. These can have a compounding effect. Delays in implementation lead to additional costs which raise financial questions which can further delay implementation. Transportation project implementation is an especially complex task, not easily given to efficiency.

4. Land use effects are largely unknown: With a few exceptions, the concepts described above have not been widely implemented and their land use effects are largely unknown. TOFC services have had some impact on the removal of conventional rail yards from the center of urban areas and their replacement with terminals in outlying areas. Both new urban toll roads and HOV facilities are difficult to assess since they are still relatively new and it is difficult to separate their effects from other factors in land use change.

Potential Land Use Effects of AHS:

Given the preceding then, how might AHS affect land use? To answer this question it is necessary to assume that AHS is widely implemented and theat the existing process of land use change and development will continue into the future. AHS will likely have impacts in three general categories: displacement effects, proximity effects and area wide effects.

Displacement Effects: Displacement effects refers to the direct impact of the taking of land for a new transportation facilities. If AHS requires new or additional right of way, this would cause a displacement effect on land use. Businesses or households would be forced to relocate because their land is required for the new facility. This leads to a lower population in the corridor and higher populations elsewhere. If the facility requires considerable displacement it can have an impact on land redistribution in a metropolitan area. In addition displacement creates economic consequences to the property owners as well as social and psychological effects. Although this may be a short term or localized effect, it can be significant because of the implementation issues mentioned previously.

Proximity Effects: Proximity effects are those that occur to residents and businesses that are located near a new or expanded facility. These are the people who remain after a facility is expanded. If for example, an AHS lane carries three times the traffic of an existing lane, this would affect increase neighborhood noise levels, air quality, neighborhood access and business activity. This could in turn affect land values, land use and regional redistribution. It would be a cause of considerable concern to those affected and would require additional expense for mitigation of effects. In addition it would be a further reason to complicate the implementation process.

Area-Wide Effects: The final area of land use effect and perhaps the most intriguing Is the issue of the effect on regional land use patterns. As described previously, significant changes in travel times on transportation facilities have led to dispersal and decentralization of land use. Improved travel times provide an opportunity to locate activities at places of lower price land or to locate at high quality sites. AHS would have a similar effect. The degree of effect depends upon how widely it is implemented and how distant we look into the future. The further into the future and the more widespread the implementation , the greater the decentralization effect. Decentralization would in turn would lead to a loss of farmland, woodlands and areas of high environmental quality. This can have serious long term consequences which may be causes of further difficulties of implementation.

The area wide effects of AHS on land use would occur both at the origin and the destination ends of trips.

Origins (locations of households) would become more dispersed. Destinations (work places and commercial areas) could become more congested as large numbers of vehicles come off of an AHS onto local streets. These larger volumes will require larger areas for parking and street capacity which may further compound the problem. Congestion levels could in turn lead to even wider dispersion as businesses and employment centers relocate to avoid the congestion.

Conclusions:

An examination of the impacts of automated highways on land use reveals some general findings. First it appears that there are major questions that would be raised if and when AHS are intended to be widely implemented. They will generate significant debate which will be dominated by non-technological issues. Many of these issues would be related to land use impacts, those directly related to implementation such as displacement and proximity effects as well as area wide consequences. The principle advantage of AHS to users, its potential for time savings is also the cause of potential negative impacts on land use. The more successful the AHS, the more it is likely to create decentralization and other land use impacts. Such issues are likely to be hotly debated at the time of deployment of AHS.

Unfortunately there are no easy ways to mitigate and minimize the negative consequences of AHS on land use. Past efforts to shape land use have been largely ineffective. Support of good planning at the state, regional and local level is essential. This should be done to minimize the negative impacts of AHS. Support should extend to preservation and protection of key areas such as environmental corridors, woodlands, wetlands, areas of native vegetation and prime, productive agricultural areas. Furthermore, AHS should be looked on as true Intermodal facilities which permit utilization by a wide variety of vehicle and user types. Sound land use planning at the local level should be supported to make such systems work effectively. Associated facilities for pedestrians, bicycles, public transit and efficient freight handling and delivery will be needed to complement the AHS. These too should be actively supported to enhance the AHS and to mitigate some of its potential effects.

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